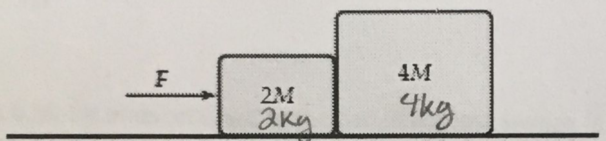
1. Which of the following is a vector?
   a. Momentum
   b. Temperature
   c. Volume
   d. Mass
   e. Density

2. An automobile moving along a straight track changes its velocity from 40 m/s to 80 m/s in a distance of 200 m. What is the (constant) acceleration of the vehicle during this time?
   a. 8.0 m/s^2
   b. 9.6 m/s^2
   c. 0.20 m/s^2
   d. 6.9 m/s^2
   e. 12 m/s^2

3. A rock is thrown downward from an unknown height above the ground with an initial speed of 10 m/s. It strikes the ground 3.0 s later. Determine the initial height of the rock above the ground.
   a. 44 m
   b. 74 m
   c. 14 m
   d. 30 m
   e. 60 m

4. The horizontal surface on which the objects slide is frictionless. If $M = 1.0$ kg and the magnitude of the force of the small block on the large block is 5.2 N, determine F.



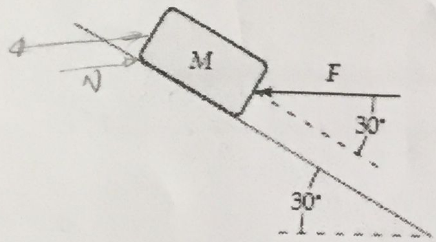
   a. 6.0 N
   b. 9.0 N
   c. 7.8 N
   d. 4.8 N
   e. 4.1 N

5. A particle leaves the origin with a velocity of 7.2 m/s in the positive y direction and moves in the xy plane with a constant acceleration of $(3.0\hat{i} - 2.0\hat{j})$ m/s^2. At the instant the particle moves back across the x axis ($y = 0$), what is the value of its x coordinate?
   a. 65 m
   b. 91 m
   c. 54 m
   d. 78 m
   e. 86 m

6. A projectile is thrown from the top of a building with an initial velocity of 30 m/s in the horizontal direction. If the top of the building is 30 m above the ground, how fast will the projectile be moving just before it strikes the ground?
   a. 35 m/s
   b. 39 m/s
   c. 31 m/s
   d. 43 m/s
   e. 54 m/s

7. In a location where the train tracks run parallel to a road, a high speed train traveling at 60 m/s passes a car traveling at 30 m/s in the opposite direction. How long does it take for the train to be 180 m away from the car?
   a. 2.0 s
   b. 3.0 s
   c. 6.0 s
   d. 9.0 s
   e. 18.0 s

8. A block is pushed up a frictionless 30° incline by an applied force as shown. If $F = 25$ N and $M = 3.0$ kg, what is the magnitude of the resulting acceleration of the block?



a. 2.3 m/s²
b. 4.6 m/s²
c. 3.5 m/s²
d. 2.9 m/s²
e. 5.1 m/s²

9. A 2.0-kg object has a velocity of 4.0**i** m/s at $t = 0$. A constant resultant force of (2.0**i** + 4.0**j**) N then acts on the object for 3.0 s. What is the magnitude of the object's velocity at the end of the 3.0-s interval?

a. 9.2 m/s
b. 6.3 m/s
c. 8.2 m/s
d. 7.2 m/s
e. 7.7 m/s

10. An open milk carton is pierced by an ice pick 10 cm below the surface of the liquid. At what speed in m/s does the liquid exit the carton?

a. 2.4
b. 1.6
c. 1.9
d. 1.4
e. 3.8

11. A 0.40-kg mass attached to the end of a string swings in a vertical circle having a radius of 1.8 m. At an instant when the string makes an angle of 40 degrees below the horizontal, the speed of the mass is 5.0 m/s. What is the magnitude of the tension in the string at this instant?

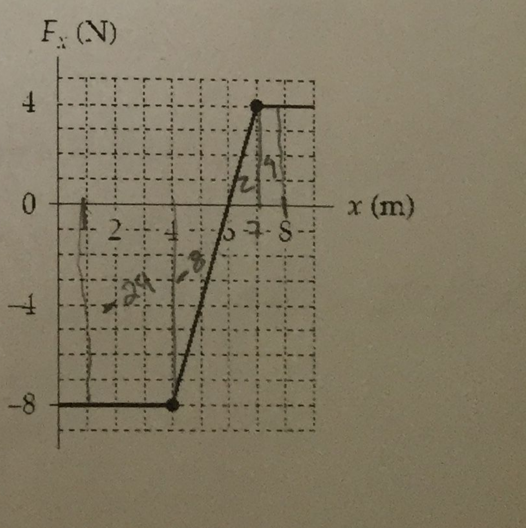
a. 9.5 N
b. 3.0 N
c. 8.1 N
d. 5.6 N
e. 4.7 N

12. A 2.5-kg object falls vertically downward in a viscous medium at a constant speed of 2.5 m/s. How much work is done by the force the viscous medium exerts on the object as it falls 80 cm?

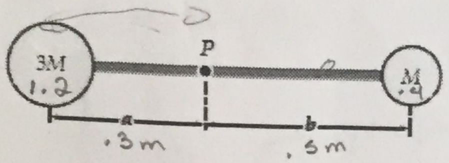
a. +2.0 J
b. +20 J
c. −2.0 J
d. −20 J
e. +40 J

13. A body moving along the x axis is acted upon by a force F_x that varies with x as shown. How much work is done by this force as the object moves from $x = 1$ m to $x = 8$ m?

a. −2 J
b. −18 J
c. −10 J
d. −26 J
e. +18 J



14. The rigid body shown is rotated about an axis perpendicular to the paper and through the point P. If $M = 0.40$ kg, $a = 30$ cm, and $b = 50$ cm, how much work is required to take the body from rest to an angular speed of 5.0 rad/s? Neglect the mass of the connecting rods and treat the masses as particles.



$\omega_0 = 0$

$\omega_f = 5$ rad/s

$I = mr^2$

$I = .208$

$\Sigma F_x = ma$

$\Sigma\tau = I\alpha$

$F_r = I\alpha$

X

a. 2.9 J
b. 1.6 J
c. 3.1 J
d. 3.4 J
e. 2.6 J

15. A particle located at the position vector $\hat{\mathbf{r}} = (\hat{\mathbf{i}} + \hat{\mathbf{j}})$ m has a force $\vec{\mathbf{F}} = (2\hat{\mathbf{i}} + 3\hat{\mathbf{j}})$ N acting on it. The torque about the origin is

a. $(1\hat{\mathbf{k}})$N · m
b. $(5\hat{\mathbf{k}})$N · m
c. $(-1\hat{\mathbf{k}})$N · m
d. $(-5\hat{\mathbf{k}})$N · m
e. $(2\hat{\mathbf{i}} + 3\hat{\mathbf{j}})$N · m

$\tau = (\hat{i} + \hat{j}) \times (2\hat{i} + 3\hat{j})$

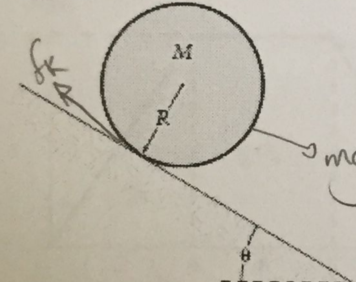
$\hat{i}\ \hat{j}\ k$

1 1

2 3

1K

16. A solid cylinder rolls without slipping down an incline as shown in the figure. The linear acceleration of its center of mass is



$I = \frac{2}{5}Mr^2$

$r\alpha = a \to \frac{a}{r} = \alpha$

$\Sigma\tau = I\alpha$

$F_k r = I\alpha$

$F_k r = \frac{2}{5}Mr^2\left(\frac{a}{r}\right)$

$F_k = \frac{2}{5}M$

$\Sigma F = ma$

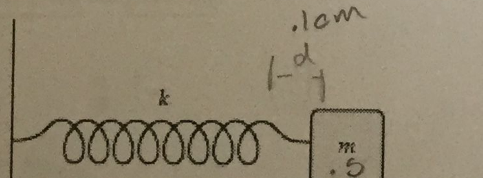
$mg\sin\theta - f_k = ma$

$mg\sin\theta - \frac{2}{5}ma = ma$

$a = \frac{5}{7}g\sin\theta$

a. $(5/7)g \sin\theta$
b. $(1/2)g \sin\theta$
c. $(2/3)g \sin\theta$
d. $(3/5)g \sin\theta$
e. $(4/5)g \sin\theta$

17. The block shown is released from rest when the spring is stretched a distance d. If $k = 50$ N/m, $m = 0.50$ kg, $d = 10$ cm, and the coefficient of kinetic friction between the block and the horizontal surface is equal to 0.25, determine the speed of the block when it first passes through the position for which the spring is unstretched.



$\frac{1}{2}kx^2$

$K_s + \Delta E_{mech} = K_m$

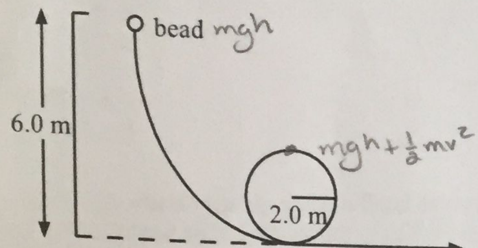
$\frac{1}{2}kx^2 + f_k = \frac{1}{2}mv^2$

$.5(50)(.10)^2 + .25(.5 \times 9.81) = .5(.5)v$

.5 +

a. 92 cm/s
b. 61 cm/s
c. 71 cm/s
d. 82 cm/s
e. 53 cm/s

18. When released, a bead slides without friction down a wire and makes a loop–the–loop as shown in the diagram (radius 2.0 m). What is its speed in m/s at the top of the circular loop?



$mgh = mgh + \frac{1}{2}mv^2$

$9.81(6) = 9.81(4) + \frac{1}{2}v$

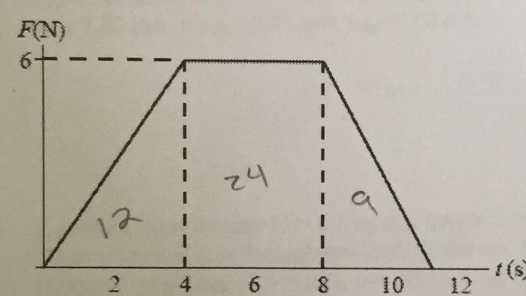
a. 13 b. 6.3 c. 8.9 d. 11 e. 7.4

19. Two masses, M_A and M_B, with $M_B = 2M_A$, are released at the same time and allowed to fall straight down. Neglect air resistance. When we compare their kinetic energies after they have fallen for equal times, we find that

a. $K_B = 2K_A$.
b. $K_B = K_A$.
c. $K_B = 4K_A$.
d. $K_A = 2K_B$.
e. $K_A = 4K_B$.

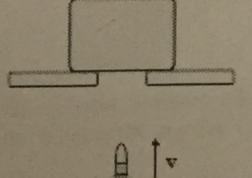
20. A 2.5 kg body, initially at rest, is acted on by the horizontal force shown in the graph. What is its speed in m/s when $t = 11$ s?

$I = \frac{\Delta p}{t}$



a. 25
b. 18
c. 45
d. 27
e. 36

21. A 10-g bullet moving 1000 m/s strikes and passes through a 2.0-kg block initially at rest, as shown. The bullet emerges from the block with a speed of 400 m/s. To what maximum height will the block rise above its initial position?



$m_1 = .01$ kg, $V_1 = 1000$ m/s → 400 m/s

$m_2 = 2$ kg, $V_0 = 0$

$m_1V_1 + m_2V_2 = m_1V_1 + m_2V_2$

$.01(1000) = 0.01(400) + 2V$

$V = 3$ m/s

a. 78 cm
b. 66 cm
c. 56 cm
d. 46 cm
e. 37 cm

22. A 4.0-kg mass has a velocity of 4.0 m/s, east when it explodes into two 2.0-kg masses. After the explosion one of the masses has a velocity of 3.0 m/s at an angle of 60° north of east. What is the magnitude of the velocity of the other mass after the explosion?

a. 7.9 m/s
b. 8.9 m/s
c. 7.0 m/s
d. 6.1 m/s
e. 6.7 m/s

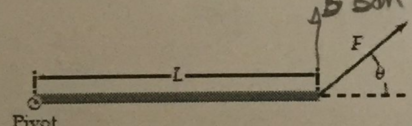
23. At $t = 0$, a wheel rotating about a fixed axis at a constant angular acceleration of -0.40 rad/s^2 has an angular velocity of 1.5 rad/s and an angular position of 2.3 rad. What is the angular position of the wheel at $t = 2.0$ s?

a. 4.9 rad
b. 4.7 rad
c. 4.1 rad
d. 4.3 rad
e. 4.5 rad

24. Fifteen identical particles have various speeds. One has a speed of 2.00 m/s, two have speeds of 3.00 m/s, three have speeds of 5.00 m/s, four have speeds of 7.00 m/s, three have speeds of 9.00 m/s, and two have speeds of 12.0 m/s. Which of the following conclusions about the average speed, the rms speed, and the most probable speed of these particles are true:

a. v_{avg}=7.80 m/s ; v_{rms}=7.41 m/s v_{mp}=7.00 m/s
b. v_{avg}=6.80 m/s ; v_{rms}=7.41 m/s v_{mp}=7.00 m/s
c. v_{avg}=6.80 m/s ; v_{rms}=6.41 m/s v_{mp}=9.00 m/s
d. v_{avg}=6.80 m/s ; v_{rms}=7.41 m/s v_{mp}=12.0 m/s
e. v_{avg}=7.80 m/s ; v_{rms}=5.41 m/s v_{mp}=7.00 m/s

25. A uniform rod of mass M = 1.2 kg and length L = 0.80 m, lying on a frictionless horizontal plane, is free to pivot about a vertical axis through one end, as shown. The moment of inertia of the rod about this axis is given by $(1/3)ML^2$. If a force (F = 5.0 N, θ = 40°) acts as shown, what is the resulting angular acceleration about the pivot point?

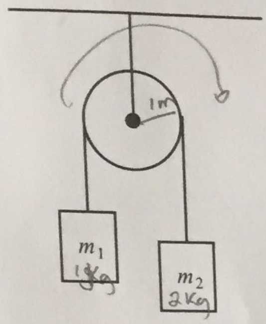


a. 16 rad/s^2
b. 12 rad/s^2
c. 14 rad/s^2
d. 33 rad/s^2
e. 10 rad/s^2

26. A solid, uniform sphere of mass 2.0 kg and radius 1.5 m rolls without slipping down an inclined plane of height 7.0 m. What is the angular velocity of the sphere at the bottom of the inclined plane?

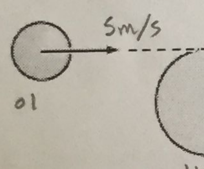
a. 5.8 rad/s b. 9.9 rad/s c. 11.0 rad/s d. 7.0 rad/s e. 6.6 rad/s

27. Two blocks, $m_1 = 1$ kg and $m_2 = 2$ kg, are connected by a light string as shown in the figure. If the radius of the pulley is 1 m and its moment of inertia is 5 kg$\cdot$m^2, the acceleration of the system in g is



a. 1/6.
b. 3/8.
c. $\frac{1}{2}$.
d. 1/8.
e. 5/8.

28. A particle of mass $m = 0.10$ kg and speed $v_0 = 5.0$ m/s collides and sticks to the end of a uniform solid cylinder of mass $M = 1.0$ kg and radius $R = 20$ cm. If the cylinder is initially at rest and is pivoted about a frictionless axle through its center, what is the final angular velocity (in rad/s) of the system after the collision?

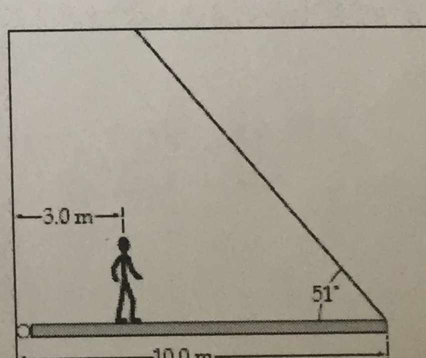


a. 8.1
b. 2.0
c. 6.1
d. 4.2
e. 10

29. The specific heat at constant volume at 0°C of one mole of a monatomic gas is

a. (3/2)R b. (1/2)R c. (5/2)R d. R e. (7/2)R

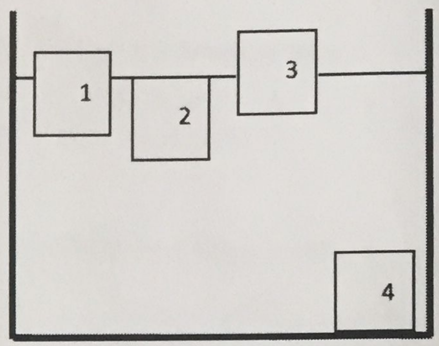
30. The figure shows a uniform, horizontal beam (length = 10 m, mass = 25 kg) that is pivoted at the wall, with its far end supported by a cable that makes an angle of 51° with the horizontal. If a person (mass = 70 kg) stands 3.0 m from the pivot, what is the tension in the cable?



a. 0.83 kN
b. 0.30 kN
c. 0.39 kN
d. 0.42 kN
e. 3.0 kN

31. In an adiabatic process
    a. the volume remains constant.
    b. the temperature remains constant.
    c. no heat is transferred between a system and its surroundings.
    d. the pressure remains constant.
    e. the internal energy is not constant.

32. Four objects of the same volume are placed carefully in the container filled with water (shown on the figure). Once placed there, none of the objects is moving with respect to the water. Which of the following statements about the masses of these objects is correct?



A) m(1) = m(2) < m(3) ≤ m(4)
B) m(3) < m(2) < m(1) < m(4)
C) m(3) < m(1) = m(2) ≤ m(4)
D) m(1) < m(2) = m(3) = m(4)
E) m(1) < m(2) = m(3) ≤ m(4)

33. A bridge is made with segments of concrete 50 m long. If the linear expansion coefficient is 12×10^{-6} (°C)$^{-1}$, how much spacing (in cm) is needed to allow for expansion during an extreme temperature change of 150° F?
    a. 10
    b. 5.0
    c. 7.5
    d. 2.5
    e. 9.5

34. How much heat (in kcal) must be removed to make ice at −10°C from 2 kg of water at 30°C? (The specific heat of water is 1.0 cal/g °C, the specific heat of ice is 0.5 cal/g °C, latent heat of fusion for water is 80 cal/g)
    a. 190
    b. 50
    c. 240
    d. 210
    e. 230

35. Three moles of an ideal gas expands isothermally at 100°C to five times its initial volume. Find the heat flow into the system.

A) 2.5×10^4 J B) 1.5×10^4 J C) 6.7×10^3 J D) 2.9×10^3 J E) 7.0×10^2 J